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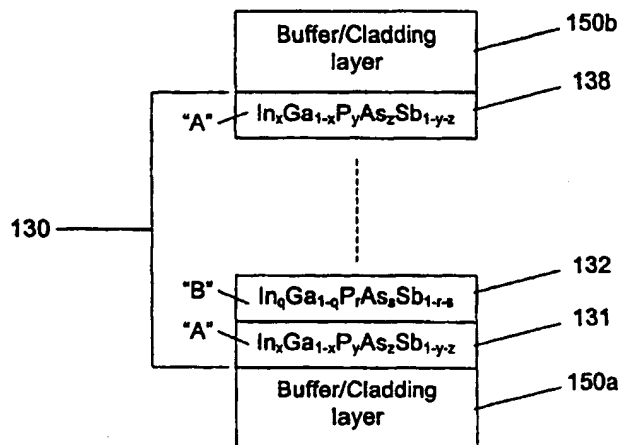
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(54) Title: COMPOUND SEMICONDUCTOR STRUCTURES FOR OPTOELECTRONIC DEVICES



(57) Abstract

A compound semiconductor device is provided that includes a substrate and an active region disposed above the substrate. The active region includes at least two different pseudomorphic layers, the first layer having the form  $\text{In}_x\text{Ga}_{1-x}\text{P}_y\text{As}_z\text{Sb}_{1-y-z}$ , and the second layer having the form  $\text{In}_q\text{Ga}_{1-q}\text{P}_r\text{As}_s\text{Sb}_{1-r-s}$ . The first layer includes at least In, Ga, and As, and the second layer includes at least Ga, As, and Sb. It is preferable for the substrate to be GaAs or  $\text{Al}_p\text{Ga}_{1-p}\text{As}$  ( $0 < p < 1$ ), or to have a lattice constant close to or equal to that of GaAs. For the first layer, it is preferable if  $x$  is between 0.05 and 0.7,  $y$  is between 0 and 0.35,  $z$  is between 0.45 and 1, and  $1-y-z$  is between 0 and 0.25. For the second layer, it is preferable if  $q$  is between 0 and 0.25 and  $1-r-s$  is between 0.25 and 1.

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# INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/US 99/28576

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 H01S5/32 H01S5/34 H01L33/00 H01S5/183 H01L31/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 H01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 767 535 A (BACHEM KARL-HEINZ ET AL) 16 June 1998 (1998-06-16)	1-3, 6-9, 11, 16-19, 23, 25-29, 45-48, 50-52
Y	column 2, line 37-42; figures 4-10	4, 5, 30-44
A	column 3, line 33-60  column 6, line 52 -column 7, line 14 column 8, line 9-62 column 10, line 34-50 --- -/-	10, 12-15, 20-22, 24

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/28576

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>DOWD P ET AL: "1.3 <math>\mu</math> m InGaAs/GaPAsSb light emitting diode grown on GaAs" TECHNICAL DIGEST. SUMMARIES OF PAPERS PRESENTED AT THE CONFERENCE ON LASERS AND ELECTRO-OPTICS. POSTCONFERENCE EDITION. CLEO '99. CONFERENCE ON LASERS AND ELECTRO-OPTICS (IEEE CAT. NO.99CH37013), TECHNICAL DIGEST. SUMMARIES OF PAPERS PRESENTED AT THE, pages 489-490, XP002137918</p> <p>1999, Washington, DC, USA, Opt. Soc. America, USA ISBN: 1-55752-595-1 the whole document</p>	<p>1-3,6-9, 11, 16-19, 23-27, 45-48, 50-52</p>
Y	<p>US 5 719 894 A (JEWELL JACK L ET AL) 17 February 1998 (1998-02-17) cited in the application column 2, line 47-66 column 6 column 14 column 18 column 34, line 58 -column 35, line 35 column 38</p>	<p>1,30-44</p>
X	<p>CHARYKOV N A ET AL: "Solid solution In/sub x/Ga/sub 1-x/As/sub y/Sb/sub z/P/sub 1-y-z/: a new material for infrared optoelectronics. I. Thermodynamic analysis of the conditions for obtaining solid solutions, isoperiodic to InAs and GaSb substrates, by liquid-phase epitaxy" FIZIKA I TEKHNIKA POLUPROVODNIKOV, APRIL 1997, AIP, RUSSIA, vol. 31, no. 4, pages 410-415, XP002137919</p> <p>ISSN: 0015-3222</p>	<p>49</p>
Y	<p>the whole document</p>	<p>1,4,5</p>
A	<p>PATENT ABSTRACTS OF JAPAN vol. 1996, no. 04, 30 April 1996 (1996-04-30) &amp; JP 07 335976 A (NIPPON TELEGR &amp; TELEPH CORP), 22 December 1995 (1995-12-22) abstract</p>	<p>1-3, 50-52</p>
A	<p>FELIX C L ET AL: "MINIINFRARED VERTICAL-CAVITY SURFACE-EMITTING LASER" APPLIED PHYSICS LETTERS,US,AMERICAN INSTITUTE OF PHYSICS. NEW YORK, vol. 71, no. 24, 15 December 1997 (1997-12-15), pages 3483-3485, XP000734764</p> <p>ISSN: 0003-6951</p> <p>the whole document</p>	<p>1,30-44</p>

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>ZHANG Y -H: "CONTINUOUS WAVE OPERATION OF INAS/INASXSB1-X MIDINFRARED LASERS" APPLIED PHYSICS LETTERS,US,AMERICAN INSTITUTE OF PHYSICS. NEW YORK, vol. 66, no. 2, 9 January 1995 (1995-01-09), pages 118-120, XP000486054 ISSN: 0003-6951 the whole document</p>	1,6,9,10

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/28576

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5767535 A	16-06-1998	WO 9526585 A DE 19580250 D DE 59502831 D EP 0752165 A JP 9510831 T	05-10-1995 27-11-1997 20-08-1998 08-01-1997 28-10-1997
US 5719894 A	17-02-1998	AU 4588597 A WO 9813879 A	17-04-1998 02-04-1998
JP 07335976 A	22-12-1995	NONE	

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